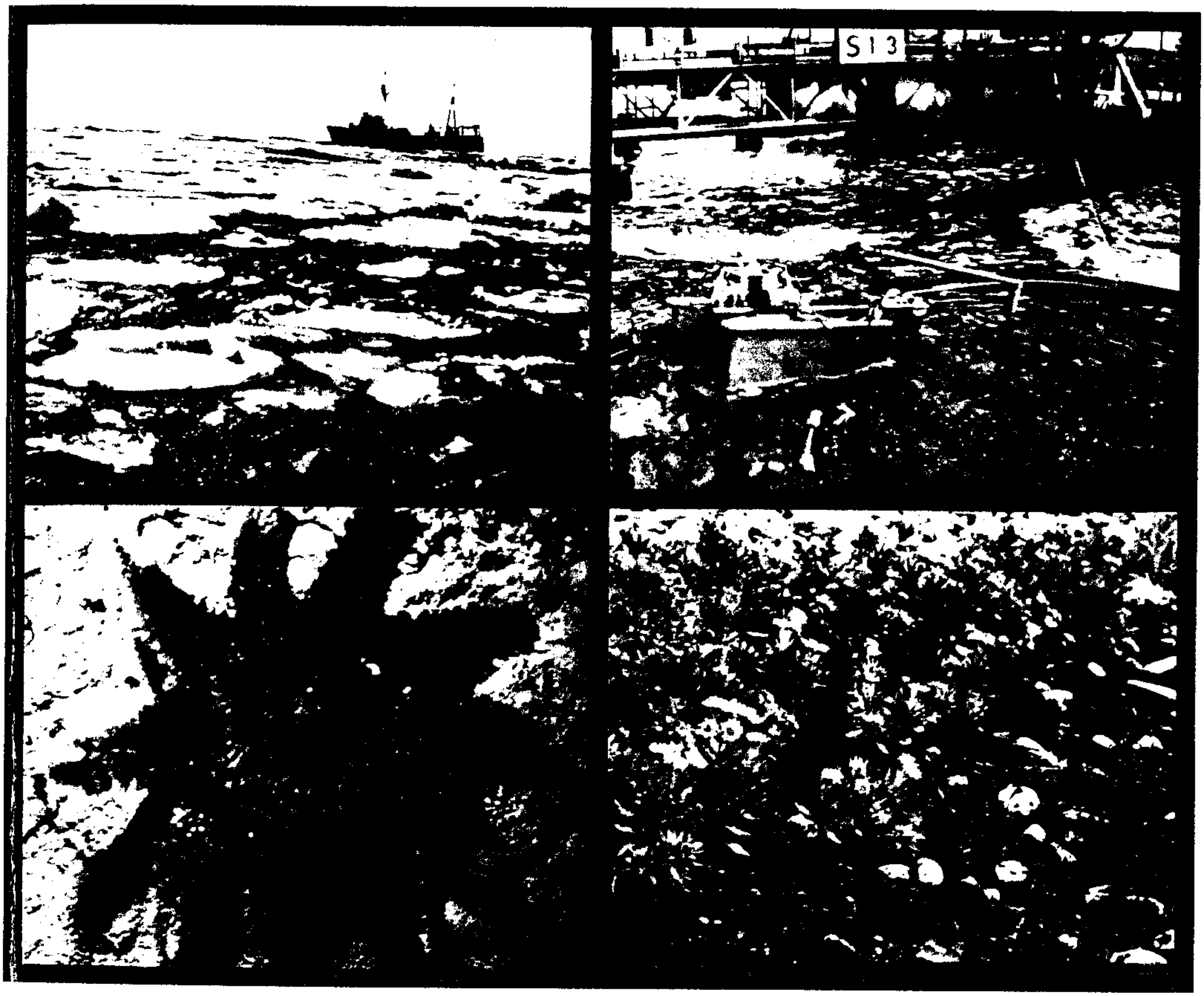
PROCEEDINGS OF THE ELEVENTH ARCTIC AND MARINE OIL SPILL PROGRAM TECHNICAL SEMINAR

COMPTES-RENDUS DE COLLOQUE TECHNIQUE DE PROGRAMME DE LUTTE CONTRE LES DEVERSEMENTS D'HYDROCARBURES DANS L'ARTIQUE



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SHIPBORNE RADAR AS AN OIL SPILL TRACKING TOOL

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Introduction

The capabilities of two x-band shipborne navigational radar units to detect oil slicks were evaluated during a joint Environment Canada-Minerals Management Service cruise offshore of Nova Scotia, Canada, in September 1987. Two series of spills were conducted; each consisted of five releases of five imperial barrels of Alberta Sweet Blend Mix (ASBM) crude and ASBM to which Bunker C had been added. The behavior of these slicks was monitored until the slicks had visually dissipated. Radar was used to track these slicks and the radar images were compared with visual observations when conditions permitted. Winds ranged from less than 10 to over 30 knots during the radar evaluation. Weather ranged from fog to rain to clear conditions.

The application of airborne x-band and synthetic aperture radar for slick detection is a proven technique with a number of worldwide operational units routinely available. Previous evaluation of shipborne radar (Axelsson, 1974) indicated that detection ranges for oil slicks were limited to approximately 1 kilometer even though the radar unit evaluated had a maximum range of 75 nautical miles. Discussions of factors influencing radar imagery conventionally describe a critical viewing angle of at least 20 degrees for sufficient reflection to yield a discernable pattern of sea surface conditions (Simanett, 1983). One evaluation of optimal antenna viewing angles (C-Core, 1981) indicated that 30 to 45 degrees from the vertical angle would be required. This lends credence to the findings of Axelsson and appears to explain the previously reported limited range of shipborne radar. However, evaluations during this cruise indicate that clear depictions of slicks are possible at ranges of 12 nautical miles or more.

One explanation of how the radar receives returns from the ocean surface is through back scattering. Microwave back scattering from the ocean surface may be due to Bragg scattering by the short (approximately 5 cm) waves for x-band radar causing a resonance in the microwave return to the antenna. This constructive interference is apparently necessary for discernable depiction of differences in sea surface texture except when breaking waves are present (Milgram, 1988). Bragg scattering is also a function of antenna viewing angle.

This evaluation of shipborne radar was predicated on the damping of short period waves by the slick and the ability of radar to detect and represent differences in the short period wave field.

Field Experiment

The joint Environment Canada-Minerals Management Service cruise to evaluate two oil spill chemical additives was conducted from the Canadian Coast Guard Cutter "Mary Hitchens" on September 9-10, 1987, offshore of Nova Scotia, Canada. Two shipboard radar units were used coincidentally to track and monitor each of the ten 5 imperial barrel oil spills during this exercise. It should be noted that an unidentified freighter transited the restricted exercise area and discharged an oil slick approximately 50 meters wide from horizon to horizon. The results of the evaluation of the chemical additives are reported elsewhere in these proceedings.

The two radars evaluated were the Sperry MK-340 and the Decca 914 with a Bright Track repeater. The Sperry MK-340 is an x-band radar with a horizontal beam width of 1.9 degrees and nominal ranges of 0.25, 0.5, 0.75, 1.5, 3, 6, 12, 14, 24, 48, and 120 nautical miles. The radar is a 50 kilowatt unit with its antenna approximately 50 feet above the ocean surface. The Decca 914 is also an x-band radar with nominal ranges of 0.25, 0.5, 0.75, 1.5, 3, 6, 12, 24, 48, and 60 nautical miles. The horizontal beam width is 1.9 degrees. The radar is a 25 kilowatt unit with an antenna height of approximately 40 feet above the ocean surface.

Results

Initial attempts to track the first five of the 5 barrel slicks over a range up to 12 nautical miles were unsuccessful with both units operating in standard navigational mode. Both radar units had sophisticated interference filters to reduce sea return and interference from rain. Approximately two hours were initially required to adjust the gain and sea and rain clutter filters to optimize the representation of the sea return. Once a relatively homogenous sea return was available on the radar, the observer analyzed areas of diminished sea return representing short wave damping due to the oil slick. The radar could subsequently be returned to navigational or slick detection mode by activating and deactivating the automatic filter program. The Decca did not offer the resolution of the Sperry and was less sophisticated so that initial adjustment for optimal sea surface return was more easily accomplished.

No photographic capabilities existed for the Sperry radar screen. The Decca Bright Track Unit allowed a wide range of screen brightness control and the following photographs were taken with this unit.

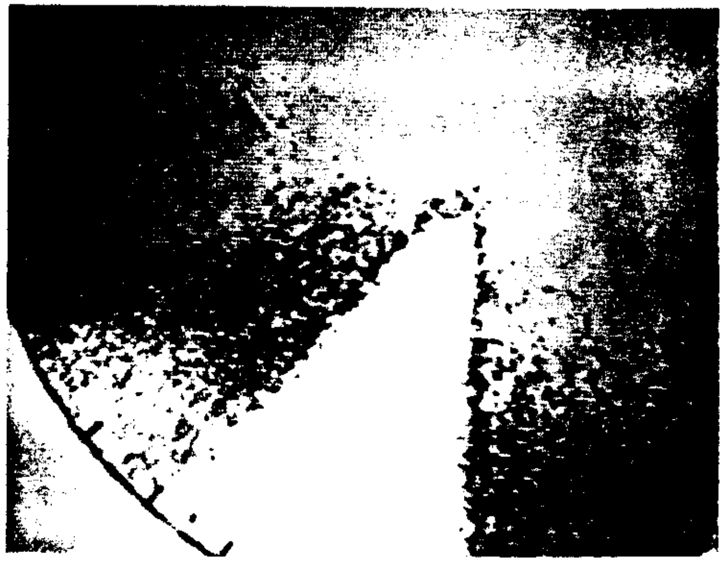

Figure 1 clearly shows the "mast shadow" artifact caused by the mounting of the radar unit just forward and starboard of the ship's mast. This pie-shaped hole in the sea return was apparent at all times.

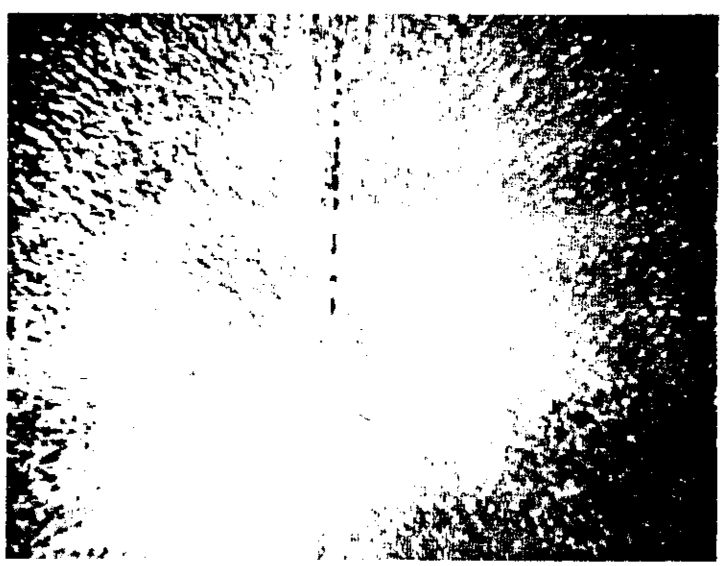

Figure 2. A five barrel slick (Slick No. 3) is visible at 11 o'clock (350 degrees relative). Range-3 nautical miles, winds 15-20 knots. The slick had deteriorated with patches of thick oil and mousse surrounded by sheen. The freighter's slick is visible at 9 o'clock (270 degrees relative).

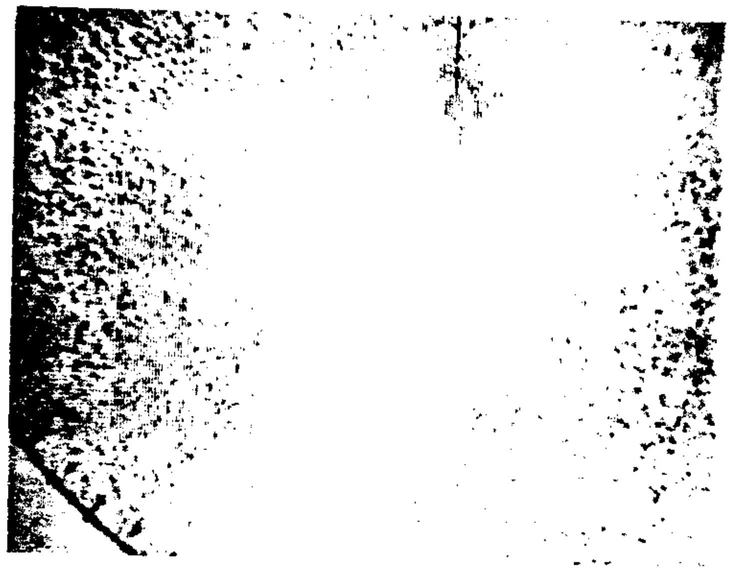

Figure 3. A slick is clearly visible from 6 to 7 o'clock (180-200 degrees relative) even though partially obscured by the mast shadow. Slick very light, mostly sheen, winds less than 10 knots. Range 3 miles.

Figure 4 shows the mast artifact from 6 to 7 o'clock (180-200 degrees relative). The slick from the freighter is visible at 4 o'clock and 9 o'clock (110 and 270 degrees relative) and was a continuous slick. A heavily dissipated sheen is visible at 12 o'clock (360 degrees relative). Range is 12 nautical miles; winds 25-30 knots.

The Decca Unit did not have the resolution of the Sperry, therefore, the photographs do not offer the detail observed during the evaluations of the Sperry.

The presence of large swells coupled with breaking wind driven waves obscured the slicks when winds exceeded 30 knots. It is unclear whether relatively advanced and confused sea states or the rapid disipation of the slick under these conditions, was responsible for the loss of detection. Perhaps both contributed to the apparent inability of either radar to find slicks in confused breaking seas. Fog and rain had no effect on the detection capabilities of either radar.

There was an apparent correlation between the observed thicker portion of the slicks and the radar image. As the slick dispersed into sheen thickness, the radar image became more indistinct. This technique apparently discerns thicker (more recoverable) slicks from less recoverable portions and could be used to guide recovery vessels, reducing unproductive efforts in slicks too thin for effective recovery.

Conclusions

Shipborne x-band radar can readily detect oil spills in a range of sea conditions if properly tuned.

Slicks were clearly detectable in winds up to 30 knots as long as major swells (8 to 10 feet) were not also present.

Slicks were detectable in 5-10 knot winds which were the minimum observed during the exercise.

Requirements for tuning the radar to optimize sea return vary with the sophistication of the unit. The higher the sophistication the more difficult the initial tuning.

Radar is a readily available tool to most responders and its use can expand slick tracking and can eliminate many of the detection problems associated with fog, rain, darkness, and relatively high sea states.

Further evaluation with a range of oils and sea states is required to quantify the limits of this technique.

Acknowledgements

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Disclaimer

The mention of specific products in this report does not constitute or imply an endorsement by the MMS or the author.

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